
Index

- age-structured population model, 162–168
- algae bloom, 42
- alternative hypothesis, 286–293, 299, 301
- Archimedes (Greek mathematician and physicist), 14, 22, 35, 196
- attained significance level (p -value), 296–297

- basic reproduction number (SIR), 171
- Bayes’ Rule, 226
- Bernoulli trial, 227, 233, 264, 267
- Bernoulli, Jacob, 237
- bin (in a histogram), 113
- binomial coefficient, 229
 - “Pascal’s triangle”, 260
- binomial distribution, 228–231, 264, 274–276
 - expected value, 237
 - variance, 240
- binomial expansion, 229
- binomial experiment, 228
- binomial random variable, 274–276
- biomass, 81
- box plot, 205

- χ^2 random variable, 276
- χ^2 -distribution, 276, 300, 301, 305
 - degrees of freedom of, 276
- California earthquakes, 117
- capture-recapture, 36, 45
- carbon cycle, 179–184
- carbon-14, 97

- carrying capacity, 139, 176
- Census MSAs, 120
- Central Limit Theorem, 254, 257–259, 273, 290, 293, 295
- Chebyshev’s theorem, 200, 256
- Chebyshev, Pafnuty, 200
- cobalt-60, 88
- compartment model, 162–188
- concave down, 105, 107
- concave up, 105, 106
- concentration, 31
- conditional probability, 223–227
- confidence interval, 265, 278–281, 292, 306
 - for population mean, 271, 272
- contingency table, 303
- continuous random variable, 241, 274, 276
- conversion factors, 5, 49
- Corpus of Contemporary American English, 121
- correlation coefficient, 194, 211
- cumulative distribution function (c.d.f.), 241

- decibels, 20
- degrees of freedom, 268, 277
- Denali caribou herd, 185
- Descartes, René, 237
- descriptive statistics, 193–218
 - correlation coefficient, 194
 - inter-quartile range (IQR), 204
 - mean, 193, 195–197

- median, 195–197
- quartiles, 201
- range, 197
- skewness, 204
- standard deviation (SD), 198–200
- difference equation, 127–157
 - affine first order, 129–131
 - characteristic equation, 147
 - first order, 129–131
 - linear, homogeneous, 147
 - linear, inhomogeneous, 147
 - second order, 145–149
- differential equations, 150
- dimensionless quantity, 27
- discrete, 128
- discrete distribution, 227
- discrete random variable, 227, 274
- distribution
 - Bernoulli trial, 227, 264
 - binomial, 228–231, 237, 240, 264, 274–276
 - χ^2 , 276
 - discrete, 227
 - exponential, 257–259
 - F , 278
 - geometric, 233–234, 239, 241
 - hypergeometric, 231, 264
 - normal, 246–251, 267
 - of sample mean, 267
 - percentage points of, 269, 271, 277, 278
 - Poisson, 234–236, 239, 241, 253, 259, 310
 - power law, 113–120, 193
 - standard normal, 246, 268, 276
 - Student's t , 268
 - uniform, 242, 244, 259
- doubling time, 96
- dynamic modeling, 127–157
- Ebola outbreak 2014–15, 90–95, 98, 171
- eigenvalues, 178
- electricity generation, 47–52
- energy usage, 47–52
- English units, 5
- epidemic (definition), 171
- epidemiological models, 168–172
- equilibrium
 - solution, 136, 140, 141, 152, 167, 177, 181, 184, 188
 - stable, 137
 - unstable, 137
- estimator, 264, 266, 267, 276, 290
 - interval, 265
 - point, 265
 - pooled for proportion, 295
- Euclid (Greek mathematician), 35
- expected value, 236–240, 245, 246, 252, 264
- exponential decay, 79–81, 174
- exponential function, 82–86, 106
- exponential growth, 79–81
 - with immigration/emigration, 132
- exponential model, 80, 86–94, 310
 - fitting, 92
- exponential random variable, 252
- F random variable, 278
- F -distribution, 278
- factorial, 229
- false negatives, 226, 288
- false positives, 226, 288
- five number summary, 205, 255
- frequency histogram, 113
 - relative, 115, 256
- function, 57–60
- functions
 - exponential, 82–86, 106
 - inverse, 82
 - linear, 60–64, 84
 - power, 103–124
- gamma function, 283
- Gause, G. F., 156
- geometric distribution, 233–234
 - expected value, 239
 - variance, 241
- geometric series
 - finite, 130, 262
 - infinite, 262
- Goethe, Johann Wolfgang von, 57
- Gosset, William S., 268
- greenhouse effect, 75
- Greenland ice sheet, 14–18
- Guinea, 95
- half-life, 88–89
- Hall, Monty, 224
- harvesting
 - constant, 152
 - greedy, 152
 - proportional, 152
 - sustainable, 152
- herd immunity, 187

- histogram, 113, 231, 235, 241, 256
 home heating, 47–52
 homoscedasticity, 307
 hybrid vehicles, 57–58
 hypergeometric distribution, 231, 264
 hypothesis
 alternative, 286–290
 null, 286–290
 hypothesis testing, 286–305
 attained significance (p -value),
 296–308
 large-sample test on a difference of
 means, 294
 large-sample test on a difference of
 proportions, 294
 large-sample test on a mean, 290
 large-sample test on a proportion, 293
 small-sample test on a mean, 295
 small-sample test on difference of
 means, 297–300
 test for equality of variances (F test),
 298–299
 testing for normality (Shapiro-Wilk),
 298
 tests on independence of categorical
 variables, 302–305
 tests on model fit, 301–302
 tests on regression coefficients,
 305–308
- independence, 226–228
 infinite geometric series, 233, 262
 inter-quartile range (IQR), 204
 intersection of sets, 222
 interval estimator, 271
 invasive species, 21
 inverse function, 82
 isotopes, 88
- Kleiber’s Law, 104, 110
 kudzu, 21
- Law of Large Numbers, 34
 Law of Total Probability, 225
 least squares, 67–69
 Libby, Willard, 97
 Liberia, 95
 linear algebra, 178
 linear function, 60–64, 84
 point-slope form, 62
 slope-intercept form, 61
 linear model, 66–75
- linear regression, 67–69, 92, 109, 193,
 211, 305–308
 log-log graph paper, 109
 log-log transform, 109
 log-log transform and regression, 120
 logarithmic scale, 13, 20, 90, 109
 logarithms, 10–14, 60, 82, 90, 107, 109
 logistic growth model, 138–141, 161
 and “chaos”, 156
 fitting, 142
 in predator-prey model, 176
 with harvesting, 151–153
 Lotka, Alfred, 173
- Massachusetts city sizes, 117
 mathematical induction, 128
 mathematical model, 65–66
 Mauna Loa CO_2 data, 72–75, 180, 183
 May, Robert, 156
 mean, 193, 195–197, 264, 273
 and law of the lever, 196
 median, 195–197
 inclusive method, 201
 mercury contamination in fish, 31, 44
 metric system, 3
 model
 age-structured population, 162–168
 basic predator-prey, 174
 compartment, 162–188
 difference equation, 127–157
 dynamic, 127–157
 epidemiological, 168–172
 exponential, 80, 86–94, 174, 310
 linear, 66–75
 logistic growth, 138–141, 161
 logistic predator-prey, 176
 power function, 103–104
 power law, 109–124
 predator-prey, 172–178
 SIR, 169–172, 186
- moment magnitude scale (earthquakes),
 20, 117
 Monty Hall problem, 224–225
 Moore’s Law, 131, 154
 Moore, Gordon, 131
 multiplier-accelerator model, 158
 mutually exclusive, 224, 227
- Napier, John, 11
 NOAA, 72, 308
 normal approximation to binomial,
 274–276, 293

- normal distribution, 246–251, 267, 295
 approximation to binomial, 274–276
 standardization formula, 247, 268, 271
 tails, 247
- normal equations, 68, 69, 193
- normal probability (QQ) plot, 298
- null hypothesis, 286–291, 293, 299, 301
- numerator and denominator degrees of freedom (F -distributions), 278
- outlier, 115, 193
 3σ rule for, 200, 208
 truncation, 209
 Tukey criterion for, 205, 208
- p -value, 296–297
- p.d.f.s and c.d.f.s, 243
- Pascal, Blaise, 237, 260
- Pearson, Karl, 301
- percent change, 28, 84, 139, 153
- percent difference, 25–28
- percent relative error, 30
- percentage points of a distribution, 269, 271, 277, 278, 290, 299
- phase portrait, 177
- point-slope form, 62
- Poisson distribution, 234–236, 253, 310
 expected value, 239
 variance, 241
- population density, 30, 43
- power (of a statistical test of hypotheses), 288, 291
- power function, 103–124
- power function model, 103–104
- power law distributions, 113–120, 193
- power law model, 109–124
 fitting, 109
- predator-prey model, 172–178
- predator-prey model, basic, 174
- predator-prey model, logistic, 176
- probability, 32–35, 221, 241
 conditional, 223–227
 normal, 247–251
 Type I error (α), 288–289
 Type II error (β), 288–289
- probability density function (p.d.f.), 241, 246
 of a χ^2 random variable, 282
 t , 268
- probability histogram, 231, 235, 241
- probability mass function (p.m.f.), 237, 261
- probability space (axioms for), 222
- proportion, 35, 45
- quartiles, 201
- R^2 -statistic, 71, 112, 116, 118, 143, 194, 211, 218, 306
- R statistical package, 254–259, 269, 278–281, 297–299, 302
- radioactive decay, 88–89
- radiocarbon dating, 97
- random variable, 227, 267
 t , 268
 Bernoulli trial, 227, 264
 binomial, 228–231, 237, 240, 264
 F , 278
 χ^2 , 276
 continuous, 241, 274, 276
 discrete, 227, 274
 exponential, 252, 257–259
 geometric, 233, 238, 241
 hypergeometric, 231, 264
 i.i.d. collection, 245, 267, 269, 272, 273
 normal, 246, 267
 Poisson, 234, 239, 241, 253, 259
 standard normal, 246, 268, 276
 uniform, 242, 244, 259
- range, 197
- ratio, 27, 84
- rejection region, 289, 292, 293, 295, 308
- residuals in regression, 71
- reverse cumulative frequency, 116
- sample, 193, 285, 286, 291
- sample space, 227
- sampling, 214–217, 263–281
- Samuelson, Paul, 158
- scaling exponent, 104, 120
- semi-log graph paper, 109
- semi-log transform, 90, 92
- set
 intersection, 222
 union, 222
- Sierra Leone, 95
- SIR model, 169–172, 186
- skewness, 197, 204
- slope of a linear function, 61–62
- slope-intercept form, 61
- solar power, 42

- sound pressure, 20
spreadsheet, 36, 70, 93, 109, 115, 141, 166, 182, 199, 207, 214–217
standard deviation (SD), 198–200, 218, 264, 267
standard error (SE), 265, 266, 306
standard normal curve, 297
standard normal distribution, 246, 268, 276
 percentage points of, 271
standard normal table, 248, 271, 276, 297
StarLink corn, 287, 295
statistic (defined), 193
statistical inference, 285–305
statistics
 descriptive, 193–218
 hypothesis testing, 286–305
 inferential, 285–305
strontium-90, 97
Student's t -distribution, 268
sustainable harvesting, 152
- t -distribution, 268, 290, 295, 308
 degrees of freedom of, 268
 percentage points of, 269
 t -table, 269, 272, 290, 295
tails of normal distribution, 247, 268
tanker oil spills, 123, 217
test statistic, 289, 290, 293–295, 299, 301, 304, 308
threshold value, 136, 152, 171, 186
Thucydides (Greek historian), 90
transient, 166
transportation, 47–52
Trendline, 70, 93, 109
Trump, Donald J., xi
truncation of outliers, 209
Tukey, John, 205
Twain, Mark, 115
Type I error, 288–289
Type II error, 288–289, 291
- uniform distribution, 242
 expected value and variance, 244
union of sets, 222
units
 English, 5
 metric, 3
uranium-235, 88
uranium-238, 88
vaccination, 172, 187
variance, 240–241, 245, 246, 252, 264, 276
Verhulst, Pierre-François, 139
vertical asymptote, 106
vertical line test, 60
Volterra, Vito, 173
vos Savant, Marilyn, 225
- Weber-Fechner Law, 10, 13, 20, 60
weighted average, 237
Wigner, Eugene, 65
with replacement, 228, 264
without replacement, 231, 264
World Health Organization, 90
- y -intercept of a linear function, 62
- Z -scores, 247–251, 290, 297
Zipf's Law, 121